Data Science and Lives Saved: The Story of Emergency Department Pediatric Readiness

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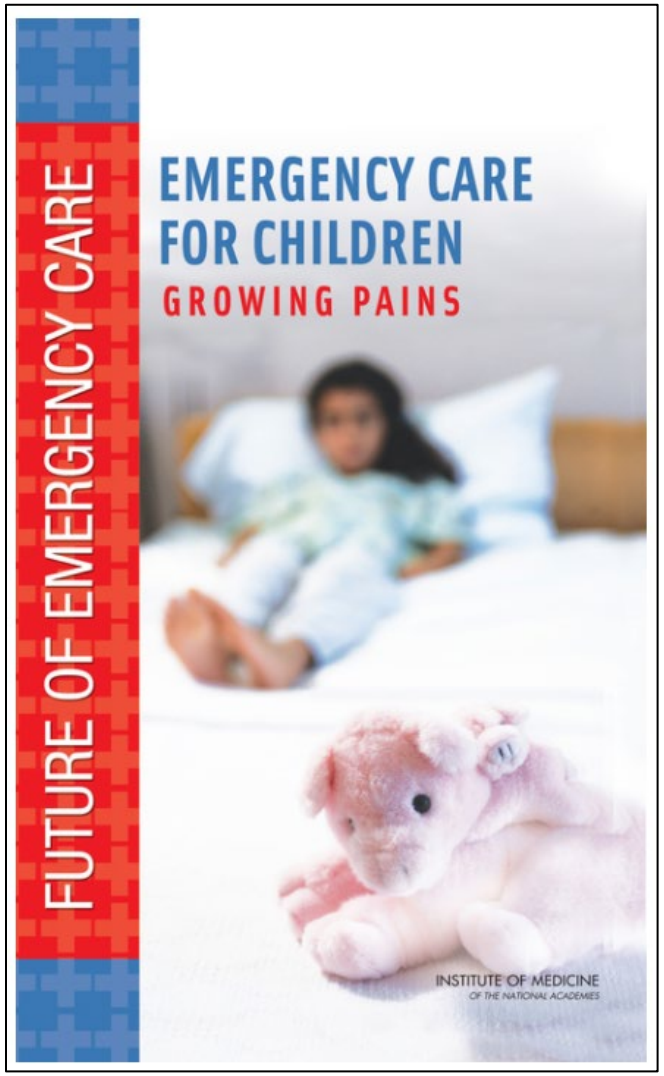
Speaker Disclosure & Funding

- National Institute of Child Health and Human Development (NICHD), #R24 HD085927
  - The Value of Pediatric Readiness in the Emergency Care of Injured Children
  - 9/30/2017 - 6/30/2023
- Health Resources and Services Administration Targeted Issues grant, #H34MC332430100
  - *A Multi-State Evaluation of Emergency Department Pediatric Readiness: Guideline Uptake and Association with Quality, Outcomes, and Cost*
  - 9/1/2019 – 8/31/2024
- NICHD, #R01 HD108017
  - Risk prediction and optimizing outcomes to 1-year after firearm injury among children using emergency services in the US
  - 9/17/2021 – 8/31/2024
- NICHD, #R01 HD109134
  - Components of ED pediatric readiness associated with short- and long-term survival among children: A mixed methods evaluation
  - 8/10/2023 – 4/30/2028

Objectives/Organization of Use Case

1. Background for ***use case***
2. Use ***case question, ultimate goals*** and ***disaster cycle phase***
3. Describe ***data sources*** in relation to conceptual model
4. ***Primary problems and barriers***, plus ***solutions*** implemented
5. Describe illustrative examples - how we used the data
6. ***Implications*** and extension of the use case

Background



- 2006 IOM/NAM report
- Large variability in emergency and trauma care for children
- Fractured care in emergency care systems across the US

Emergency Department (ED) Pediatric Readiness

- Collaboration of:
  - HRSA (EMSC program)
  - American College of Emergency Physicians (ACEP)
  - American Academy of Pediatrics (AAP)
  - Emergency Nurses Association (ENA)
- Developed methods to measure ED readiness
  - National guidelines for ED care of children
- 6 domains:
  - Policies, procedures, protocols
  - Patient safety
  - Equipment and supplies
  - Quality improvement
  - Personnel
  - Administration and coordination

- Overall score = ***Weighted Pediatric Readiness Score*** (wPRS) 0-100

Original Investigation

A National Assessment of Pediatric Readiness of Emergency Departments

Marianne Gausche-Hill, MD; Michael Ely, MHRM; Patricia Schmuhl, BA; Russell Telford, MA; Katherine E. Remick, MD; Elizabeth A. Edgerton, MD, MPH; Lenora M. Olson, PhD, MA

- 2013 national assessment
- 4,149 EDs
- Median WPRS 68.9 (IQR 56.1 – 83.6)
- Large variability in ED pediatric readiness

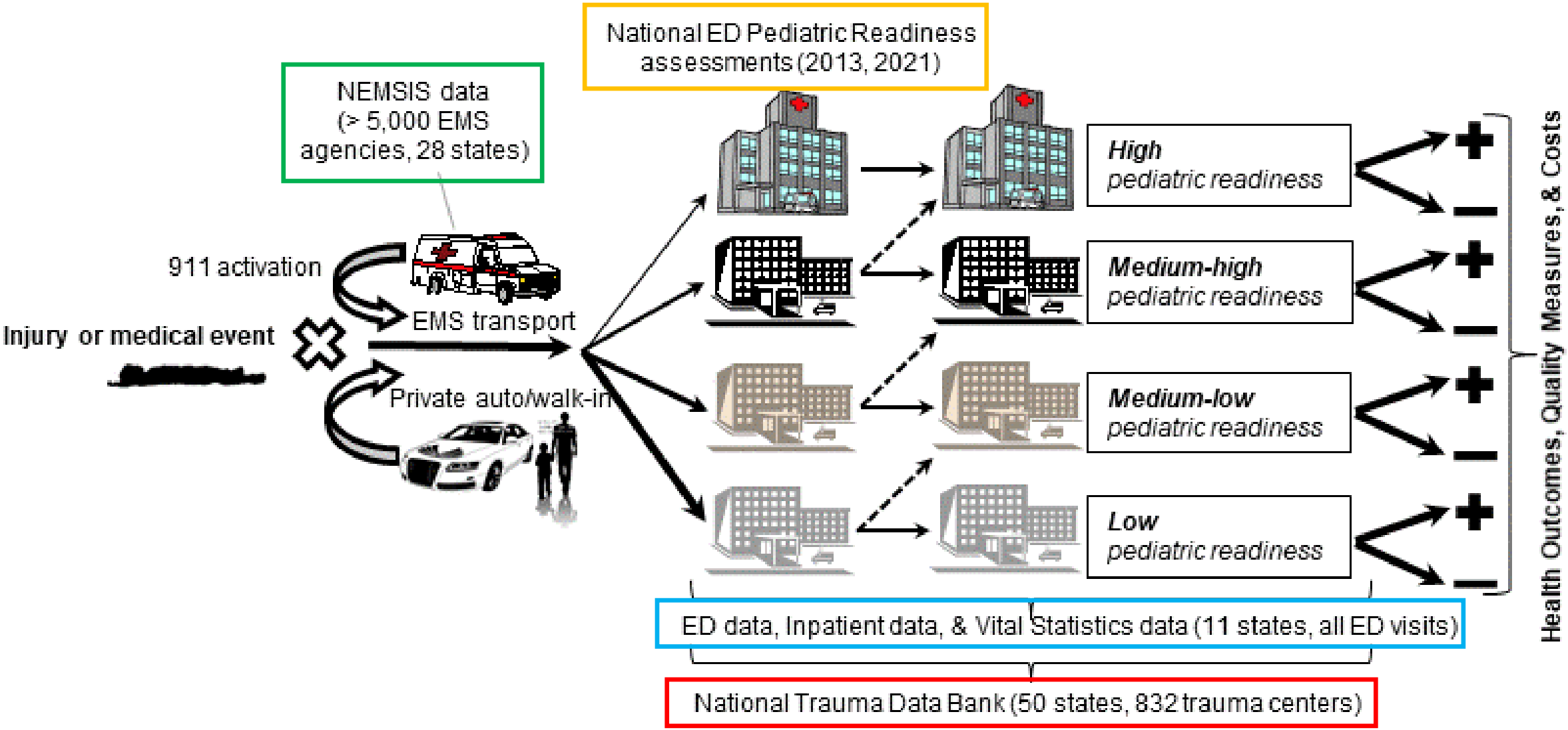
Use Case Question, Goals & Disaster Cycle

- **Question:** Is ED pediatric readiness associated with survival?

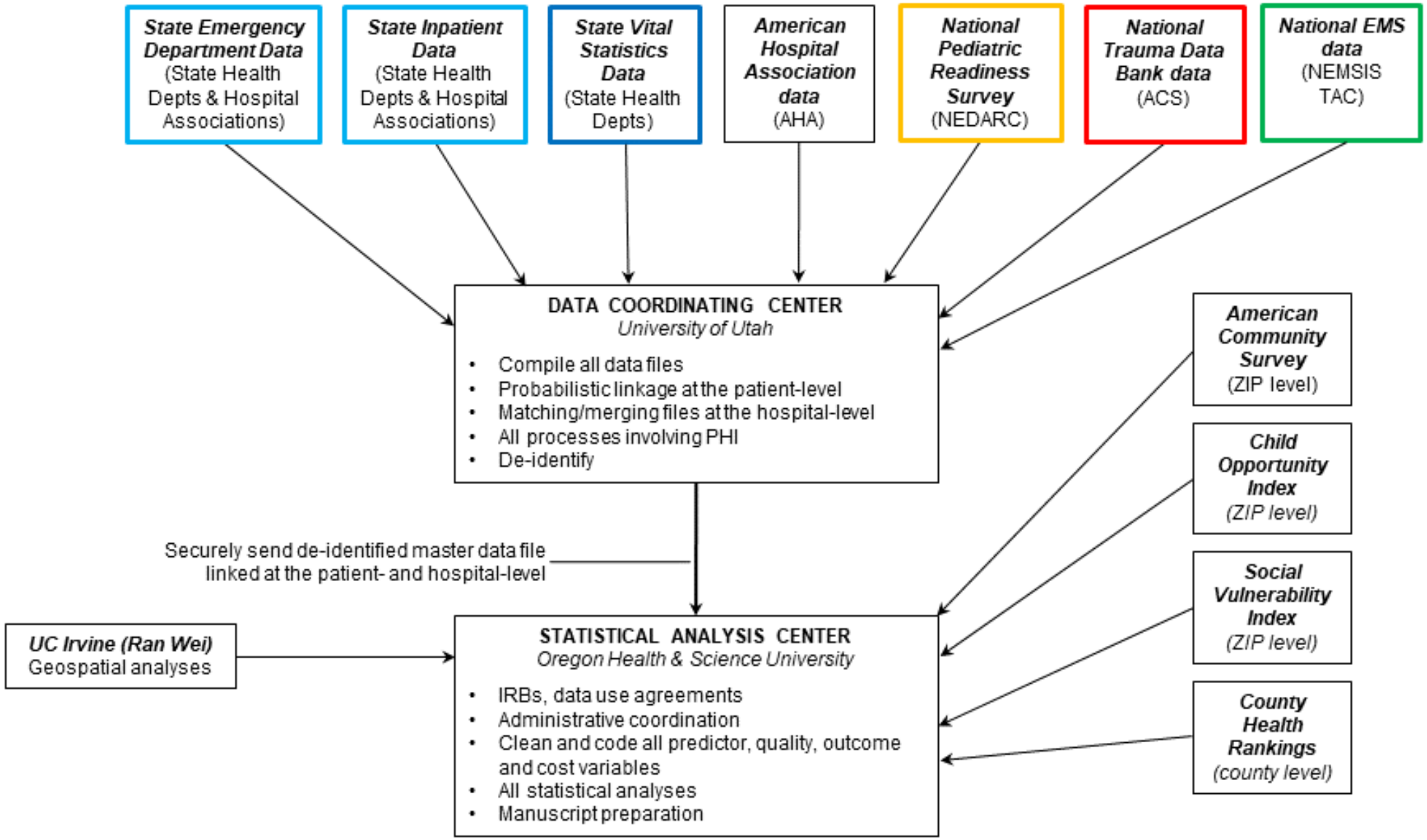
- **Ultimate goals:**
  - Relationship between ED pediatric readiness and survival
  - Threshold of ED readiness to improve survival
  - Cost and cost effectiveness
  - *Raise all EDs in the U.S. to a level of preparedness that improves pediatric survival*
    - Capacity to handle daily emergencies, plus disasters, with improved outcomes

- **Disaster Cycle Phase:** Preparedness

Conceptual model + Data Sources



Data Sources



Primary Problems & Barriers

1. ***Regulatory challenges***
   - Identifiable data from many sources
   - 28 state and federal agencies
     - Data approval committees
     - 20+ IRBs
   - Separate applications and DUAs for each project (≈ 100)
   - Different processes and issues w each state/agency

2. ***Timeliness of data***
   - 6-12 months after completion of calendar year
   - State internal data linkage slow
   - Further disruptions with pandemic and funding challenges

Solutions

- Persistence & creativity
- Established relationships with agencies, trust (“good stewards of the data”)
- Familiarity with data processes and forms
  - Applications and DUAs
- Multiple data sources, parallel processing
  - EMS (NEMSIS)
  - Trauma Centers (NTDB)
  - EDs (SEDD and SID data for 11 states, all visits)
- Study contact/collaborator at each data organization and state

Illustrative Examples: How We Used The Data

Methods

- 3 large cohorts of children:
  - 11 states, all ED visits for children (n = 983 hospitals)
  - 50 states, all trauma admissions for children (n = 832 trauma centers)
  - 50 states, all 9-1-1 EMS responses for children (> 14,000 EMS agencies)
- Analytic methods
  - Probabilistic linkage
  - Multiple imputation
  - Hierarchical modeling, cluster adjusted analyses
  - Geospatial analysis
  - Machine learning
- 4 grants = synergy and building on developed data infrastructure

JAMA Pediatrics | Original Investigation

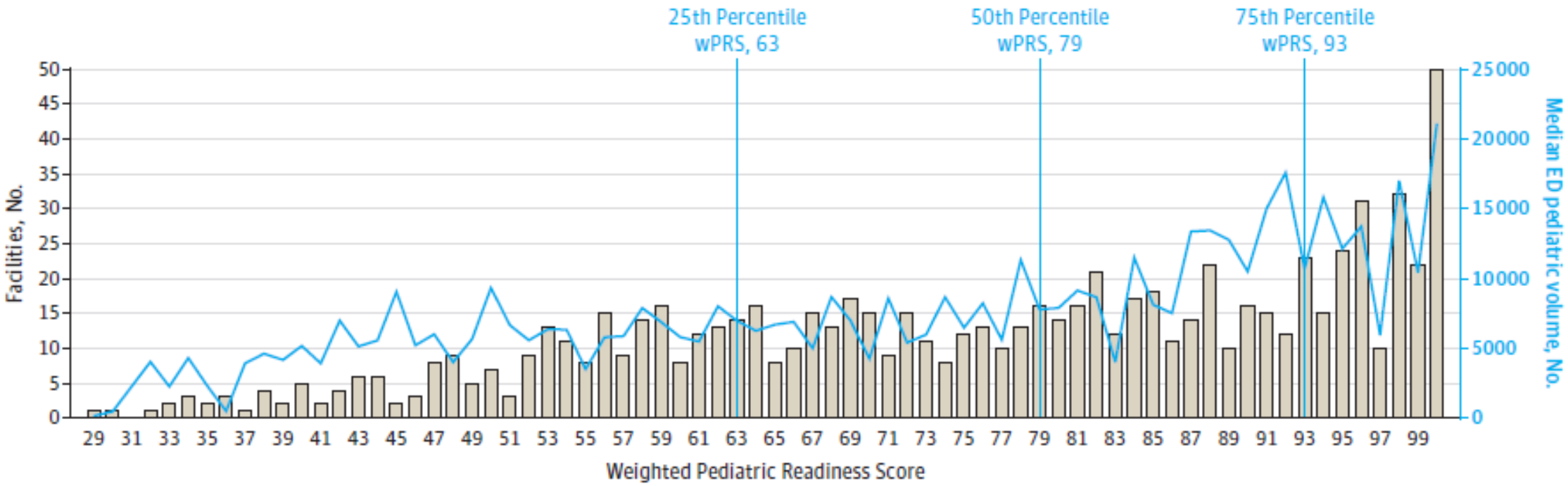
Evaluation of Emergency Department Pediatric Readiness and Outcomes Among US Trauma Centers

Craig D. Newgard, MD, MPH; Amber Lin, MS; Lenora M. Olson, PhD; Jennifer N. B. Cook, GCPH; Marianne Gausche-Hill, MD; Nathan Kuppermann, MD, MPH; Jeremy D. Goldhaber-Fiebert, PhD; Susan Malveau, MS; McKenna Smith, BS; Mengtao Dai, MS; Avery B. Nathens, MD, PhD; Nina E. Glass, MD; Peter C. Jenkins, MD, MSc; K. John McConnell, PhD; Katherine E. Remick, MD; Hilary Hewes, MD; N. Clay Mann, PhD, MS; for the Pediatric Readiness Study Group

- 832 trauma centers across U.S. (National Trauma Data Bank)
- Matched to 2013 National Assessment of ED Pediatric Readiness
- n = 372,004 injured children 0-17 years

Large Variability in ED pediatric readiness among U.S. Trauma Centers

Figure 1. Emergency Department (ED) Pediatric Readiness and Annual ED Pediatric Volume in 832 Trauma Center EDs

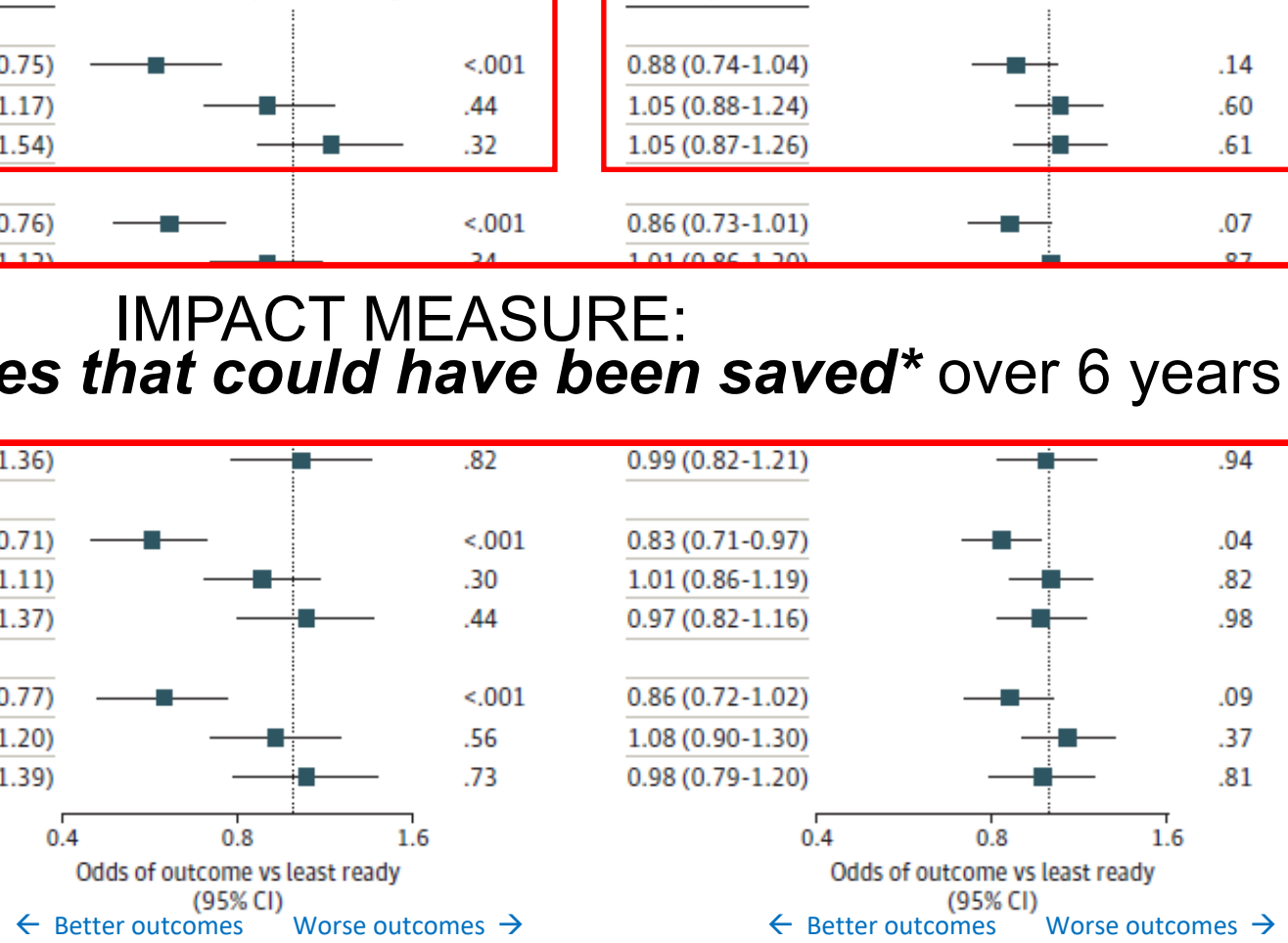


Gray bars indicate the number of EDs at each weighted pediatric readiness score (wPRS) and the blue line indicates the median annual ED volume of children at each wPRS.

Adjusted OR of outcomes (compared to least ready quartile)

Figure 2. Adjusted In-Hospital Mortality and Composite Outcome (In-Hospital Mortality or Complication) Across Quartiles of Emergency Department (ED) Pediatric Readiness for Injured Children

Variable	OR (95% CI)	In-hospital mortality	*P* value	OR (95% CI)	Combined outcome	*P* value
All patients (n = 372 004)						
4th Quartile	0.58 (0.45-0.75)		<.001	0.88 (0.74-1.04)		.14
3rd Quartile	0.90 (0.70-1.17)		.44	1.05 (0.88-1.24)		.60
2nd Quartile	1.16 (0.87-1.54)		.32	1.05 (0.87-1.26)		.61
ISS ≥16 (n = 50 440)						
4th Quartile	0.61 (0.49-0.76)		<.001	0.86 (0.73-1.01)		.07
3rd Quartile	0.90 (0.72-1.12)		.24	1.01 (0.86-1.20)		.87
2nd Quartile	1.03 (0.78-1.36)		.82	0.99 (0.82-1.21)		.94
Any AIS ≥3 (n = 124 507)						
4th Quartile	0.57 (0.45-0.71)		<.001	0.83 (0.71-0.97)		.04
3rd Quartile	0.88 (0.70-1.11)		.30	1.01 (0.86-1.19)		.82
2nd Quartile	1.05 (0.80-1.37)		.44	0.97 (0.82-1.16)		.98
High resource needs (n = 32 671)						
4th Quartile	0.60 (0.46-0.77)		<.001	0.86 (0.72-1.02)		.09
3rd Quartile	0.93 (0.72-1.20)		.56	1.08 (0.90-1.30)		.37
2nd Quartile	1.05 (0.79-1.39)		.73	0.98 (0.79-1.20)		.81



IMPACT MEASURE:
756 pediatric ***lives that could have been saved**** over 6 years

ED pediatric readiness was measured using the weighted Pediatric Readiness Score (wPRS). The x-axis is in the natural logarithm (ln) scale.

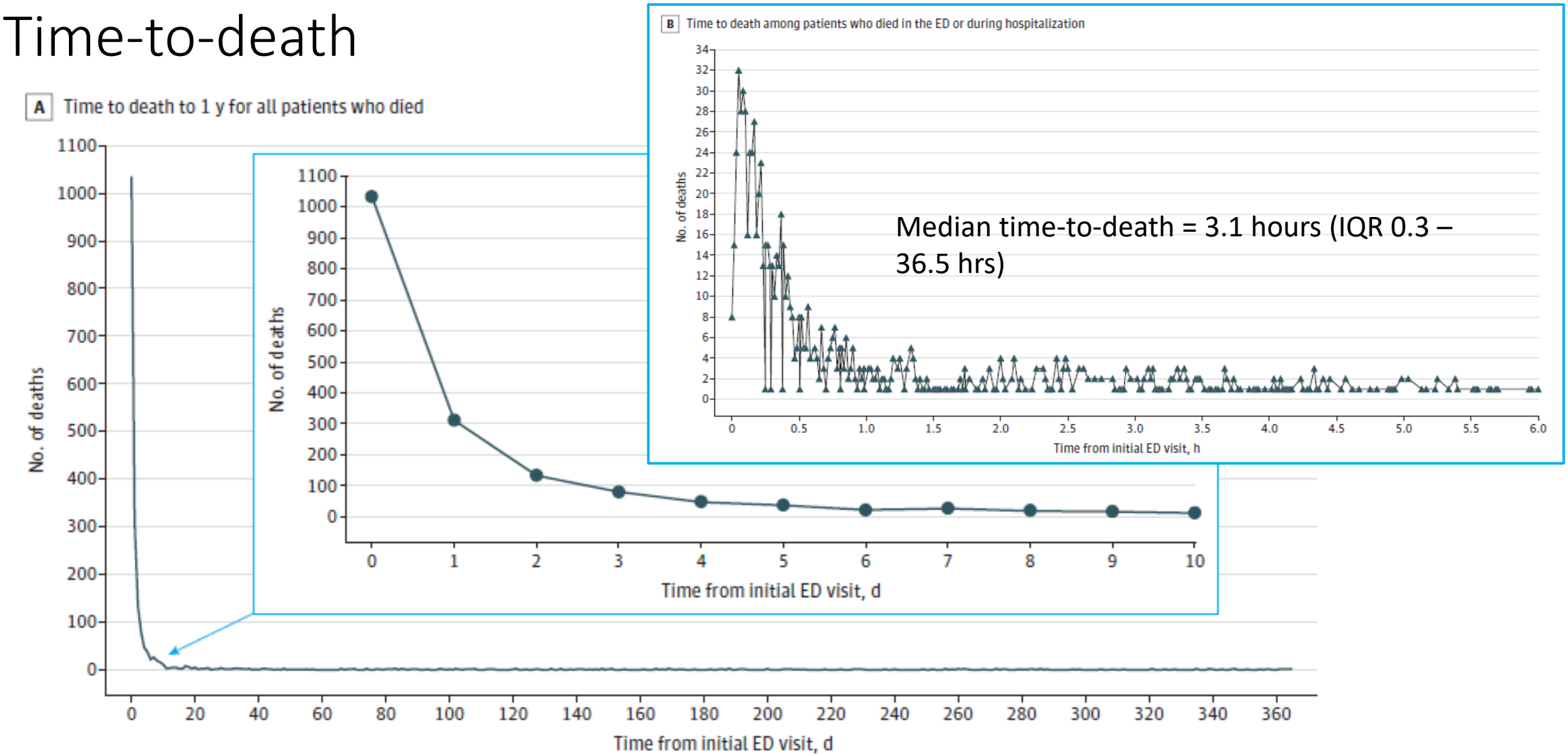
JAMA Surgery | Original Investigation

Association of Emergency Department Pediatric Readiness With Mortality to 1 Year Among Injured Children Treated at Trauma Centers

Craig D. Newgard, MD, MPH; Amber Lin, MS; Jeremy D. Goldhaber-Fiebert, PhD; Jennifer R. Marin, MD, MSc; McKenna Smith, MPH; Jennifer N. B. Cook, GCPH; Nicholas M. Mohr, MD, MS; Mark R. Zonfrillo, MD, MSCE; Devin Puapong, MD; Linda Papa, MD, MSc; Robert L. Cloutier, MD, MCR; Randall S. Burd, MD, PhD; for the Pediatric Readiness Study Group

- ED pediatric readiness and 1-year outcomes
- 146 trauma centers in 15 states (National Trauma Data Bank)
- Matched to 2013 National Assessment of ED Pediatric Readiness
- Linked each visit to Vital Statistics (death) records
- n = 88,071 injured children

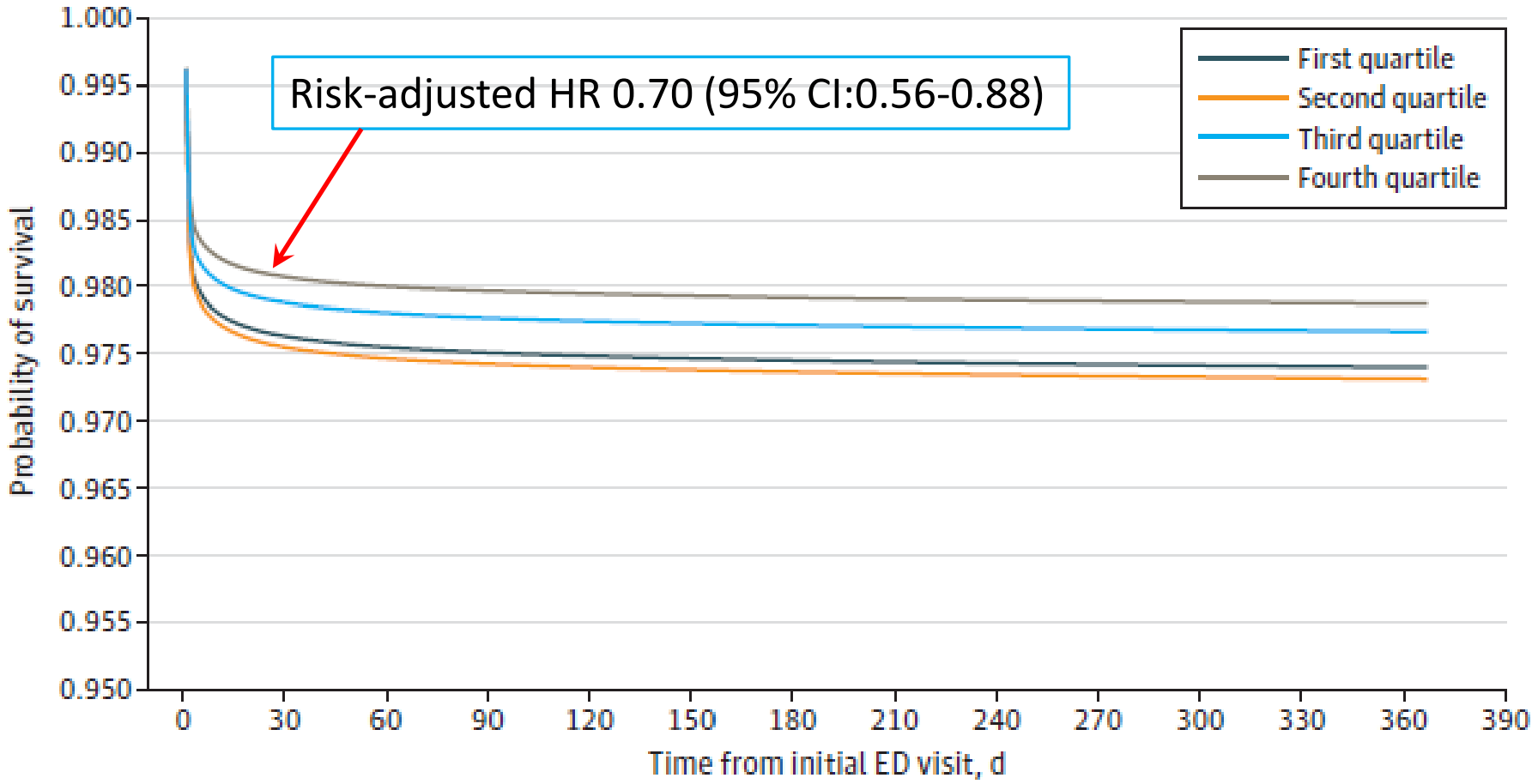
Time-to-death



Median time-to-death = 1 day (IQR 1-4)

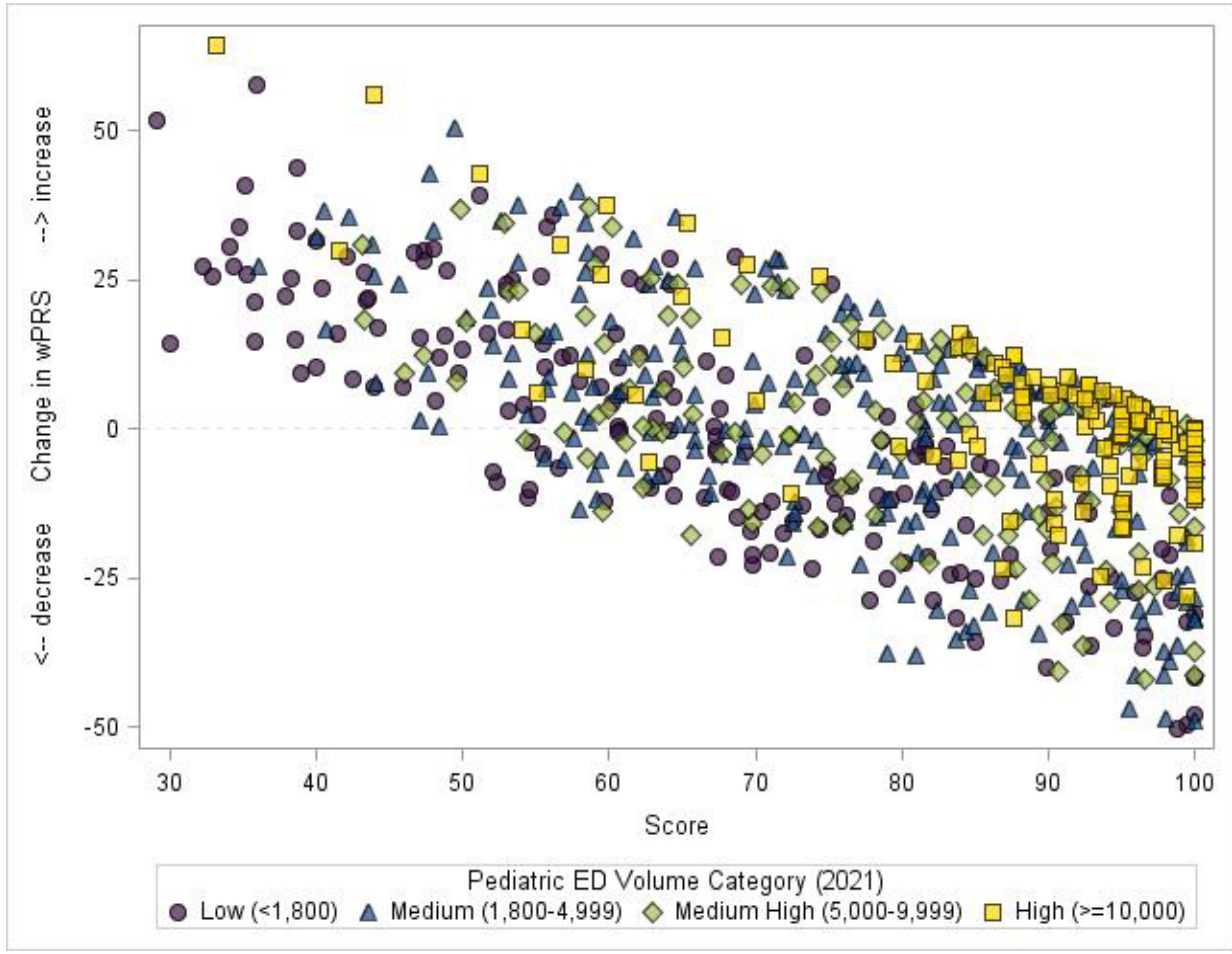
Adjusted time-to-death (1-year)

Figure 3. Adjusted Time-to-Death Analysis Among 88 071 Injured Children Presenting to 146 Trauma Centers by Emergency Department (ED) Pediatric Readiness

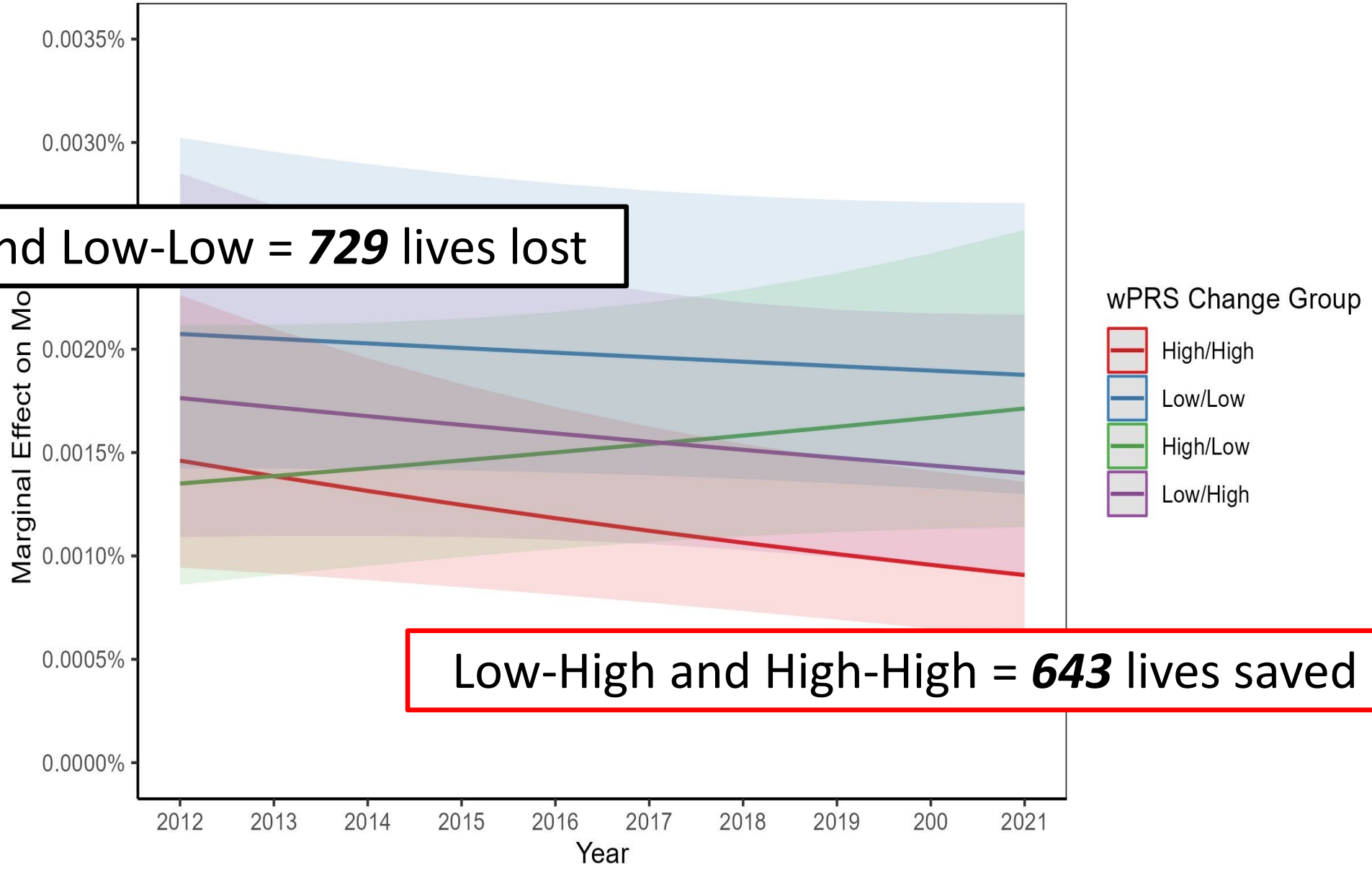


Changes in ED pediatric readiness over time at US Trauma Centers (under review)

- National Trauma Data Bank (2012-2022)
- Matched to 2013 & 2021 National Assessment of ED Pediatric Readiness
- N = 716 trauma centers
- N = 467,932 injured children



High-Low and Low-Low = ***729*** lives lost



Low-High and High-High = ***643*** lives saved

JAMA Network | Open

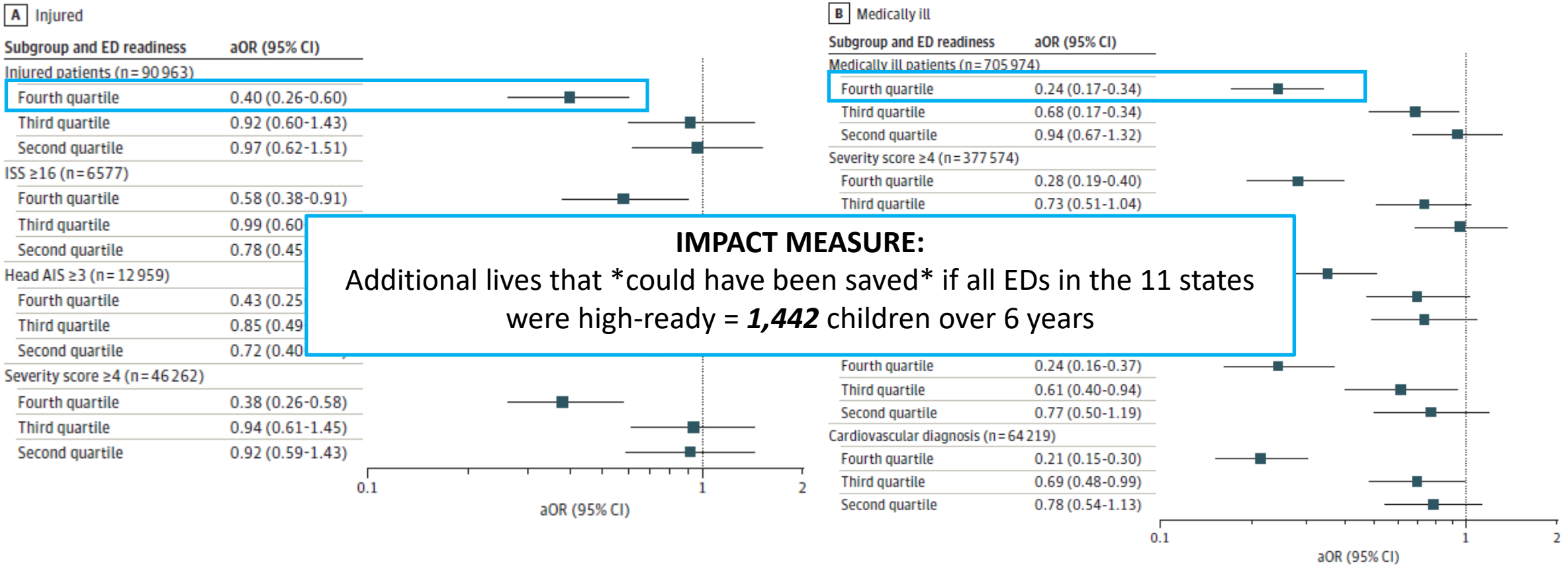
Original Investigation | Emergency Medicine

Emergency Department Pediatric Readiness and Short-term and Long-term Mortality Among Children Receiving Emergency Care

Craig D. Newgard, MD, MPH; Amber Lin, MS; Susan Malveau, MS; Jennifer N. B. Cook, GCPH; McKenna Smith, MPH; Nathan Kuppermann, MD, MPH; Katherine E. Remick, MD; Marianne Gausche-Hill, MD; Jeremy Goldhaber-Fiebert, PhD; Randall S. Burd, MD, PhD; Hilary A. Hewes, MD; Apoorva Salvi, MS; Haichang Xin, PhD; Stefanie G. Ames, MD, MS; Peter C. Jenkins, MD, MSc; Jennifer Marin, MD, MS; Matthew Hansen, MD, MCR; Nina E. Glass, MD; Avery B. Nathens, MD, PhD; K. John McConnell, PhD; Mengtao Dai, MS; Brendan Carr, MD, MS; Rachel Ford, MPH; Davis Yanez, PhD; Sean R. Babcock, MS; Benjamin Lang, MD; N. Clay Mann, PhD, MS; for the Pediatric Readiness Study Group

- 983 EDs in 11 states (State Emergency Department and Inpatient Data)
- Matched to 2013 National Assessment of ED Pediatric Readiness
- Linked each visit to Vital Statistics (death) records
- n = 796,937 children receiving emergency services

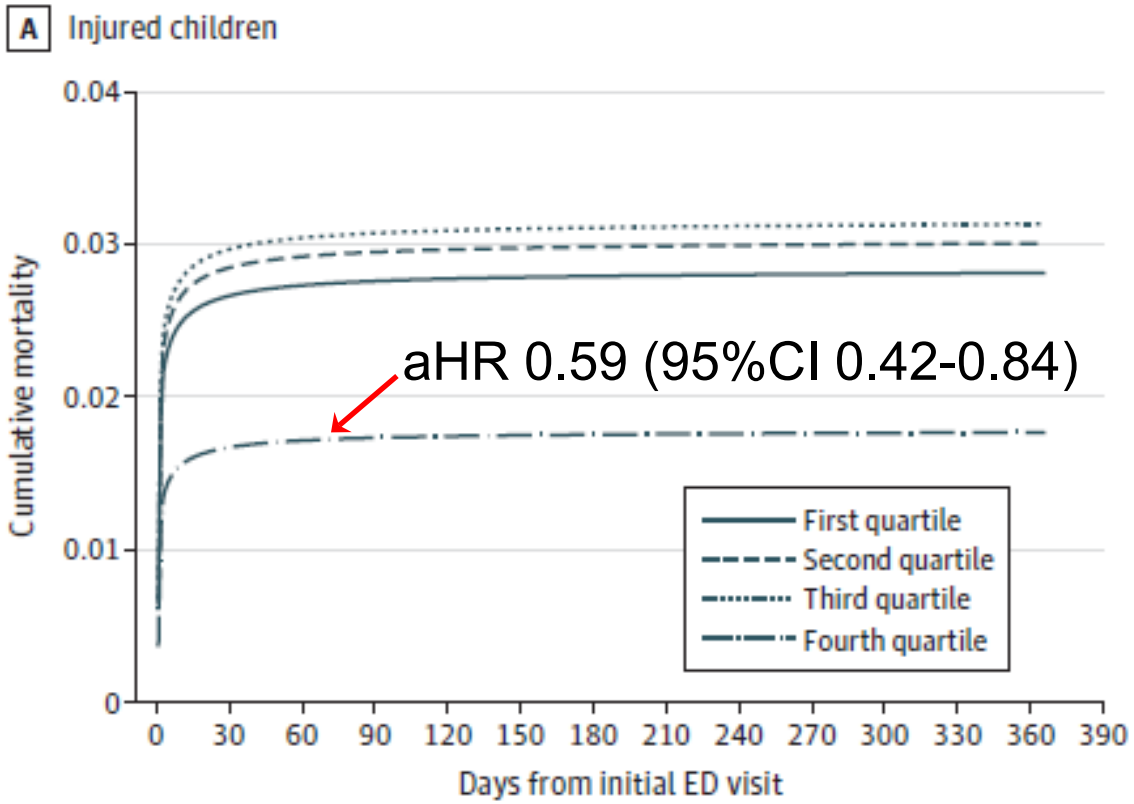
ED/in-hospital risk-adjusted mortality

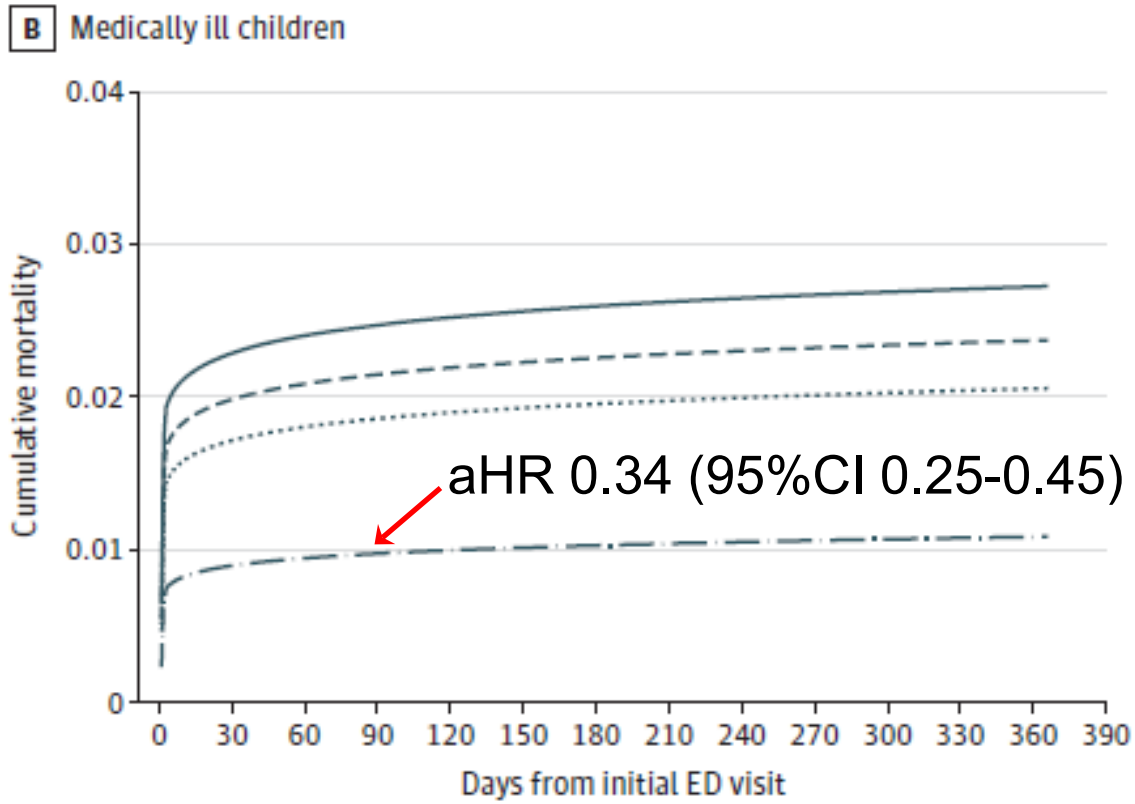


IMPACT MEASURE:

Additional lives that *could have been saved* if all EDs in the 11 states were high-ready = ***1,442*** children over 6 years

Adjusted mortality to 1-year (n = 545,921)





Timing and causes of death to 1 year among children presenting to emergency departments

Stefanie G. Ames MD, MS[1] | Apoorva Salvi MS[2] | Amber Lin MS[2] | Susan Malveau MS[2] | N. Clay Mann PhD, MS[1] | Peter C. Jenkins MD, MSc[3] | Matthew Hansen MD, MCR[2] | Linda Papa MD, MSc[4] | Sabrina Schmitz MD[2] | Cesar Sabogal MD[2] | Craig D. Newgard MD, MPH[2] | for the Pediatric Readiness Study Group

- State Emergency Department and Inpatient Data
- Linked each visit to Vital Statistics (death) records
- n = 8,043 pediatric deaths within 1 year among children receiving emergency services
- 1,356 deaths after presenting with injury
  - 693 (51.1%) in ED
  - 581 (42.9%) inpatient
  - 82 (6.1%) post-discharge
- 6,687 deaths after presenting with acute medical illness
  - 4,150 (62.1%) in ED
  - 931 (13.9%) inpatient
  - 1,606 (24.0%) post-discharge

A Geospatial Evaluation of 9-1-1 Ambulance Transports for Children and Emergency Department Pediatric Readiness

Craig D. Newgard[a], Susan Malveau[a], N. Clay Mann[b], Matthew Hansen[a], Benjamin Lang[c], Amber Lin[a], Brendan G. Carr[d], Cherisse Berry[e], Kyle Buchwalder[a], E. Brooke Lerner[f], Hilary A. Hewes[b], Shana Kusin[a], Mengtao Dai[b], and Ran Wei[g] on behalf of the Pediatric Readiness Study Group

- n=808,536 children transported by ambulance in 28 states, 2012-2019 (NEMSIS)
- Matched to 2013 National Assessment of ED Pediatric Readiness
- 2,261 receiving hospitals

- 411,685 (50.9%) transported to high-readiness EDs
- 180,547 (22.3%) had high-ready ED within 30-minute drive

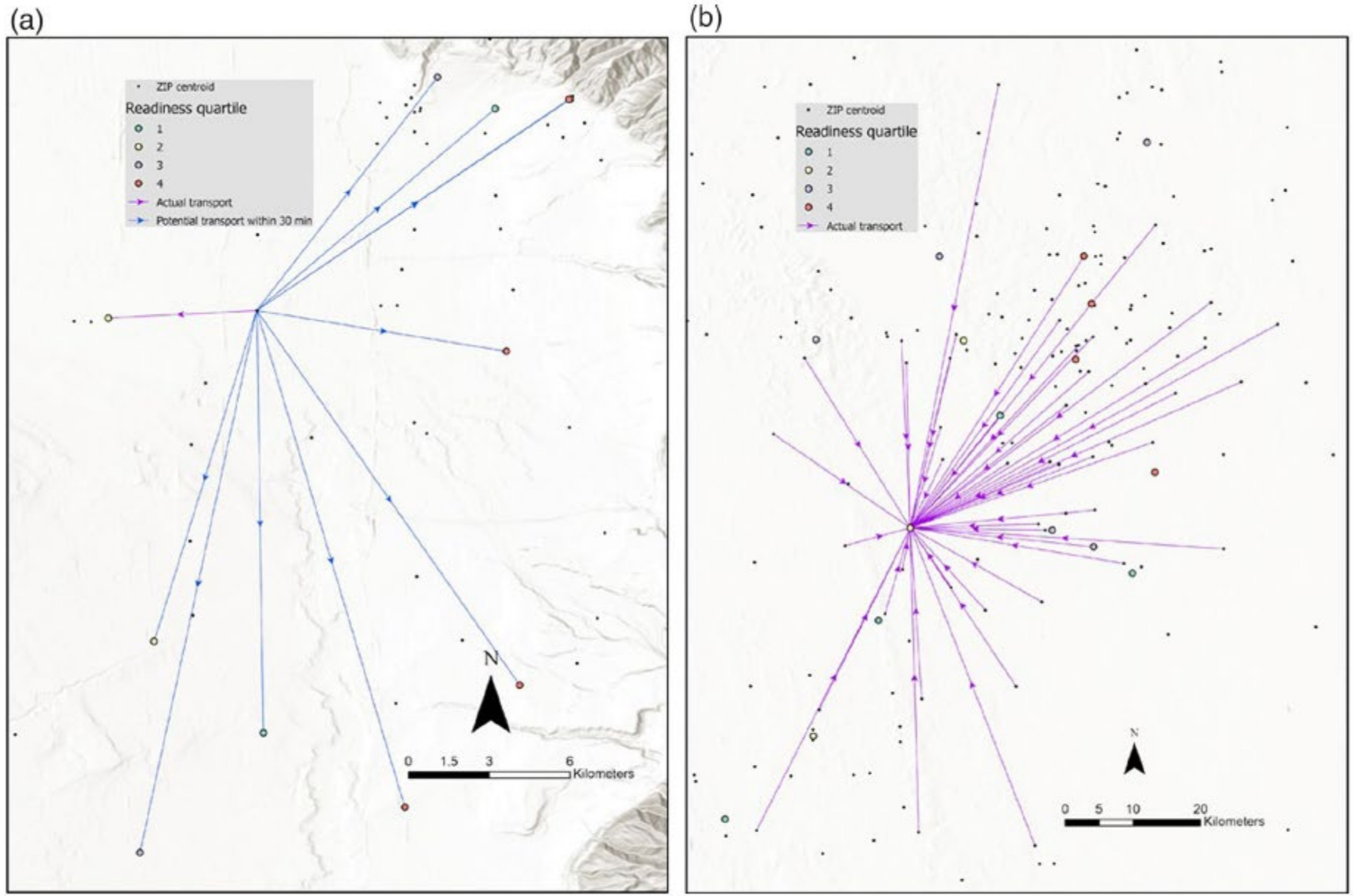


Figure 4. Sample geospatial maps of emergency department options by quartile of ED pediatric readiness for children requiring ambulance transport.
A. Spider map originating at the scene.
B. Spider map originating at a receiving hospital ED in the second quartile of ED pediatric readiness.

Implications

- Extension to extreme climate events, mass casualty incidents, large scale disasters
- Development of ‘readiness’ in other fields:
  - OB/GYN
  - Neonatal care
  - Older adults
- Consider different systems of care
  - EMS vs. ED vs. inpatient (complementary roles)
  - What are the existing networks?
  - What aspects are modifiable?
- Understand timing/urgency of different conditions and patients

Thank you!